EXHIBIT 17

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CISCO SYSTEMS

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OSPF Protocol Graceful Shutdown

Software Functional Specification

This describes the implementation of graceful shutdown for OSPF at router and interface level.

Reviewers

Department	Name/Title
Development Engineering	
DevTest Engineering	

The departments and/or individuals listed above should be notified in advance and given a sufficient time period to review this document. The Project Team determines requirements for approval according to the scope of the project.

Modification History

Revision	Date	Originator	Comments
1	09/03/2003	Shubhra Bhargava	Initial Draft
2	09/12/2003	Shubhra Bhargava	Changes based on review feedback.
3	08/09/2006	Shubhra Bhargava	Changes based on review feedback
4	08/25/2006	Shubhra Bhargava	Changes based on review feedback
5	09/19/2006	Shubhra Bhargava	Changes based on review feedback

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1 Problem Definition

Currently in IOS OSPF there is no way to gracefully shutdown the protocol. Graceful shutdown is a technique of removing the OSPF router or interface from a network with minimal disruption by leveraging existing protocol and technology capabilities. This feature will be useful in customer networks where NSF/SSO is currently not available. This is different from the NSF because here the router actively discourages its neighbors from sending it traffic.

2 Software Architecture

This implementation will allow graceful shutdown of the OSPF protocol. It will provide the capability to temporarily shutdown a protocol (without losing the configuration) and will be very useful to customers during troubleshooting and maintenance upgrades. During this operation network convergence is initiated by the router, rather than passively determined by the expiration of the neighbor timer. Hence, this will result in shorter convergence time, less network churn and greater availability.

As mentioned below, in Section 6, OSPF would introduce a new CLI at the router/protocol level and also at the interface level.

At the router level, we will completely shutdown the OSPF operation for this OSPF instance by purging the database, removing OSPF routes from the RIB for this process-ID and taking the adjacencies down ASAP. To effectively remove the router from the area topology, we will flood the Maxaged Router-LSA and kill OSPF. This MaxAge Router-LSA is not guaranteed to reach the neighbors and we would not try to retransmit the MaxAged Router LSA as that represents the best-effort nature. In the case where neighbor did not receive the MaxAge Router LSA, empty hello mechanism should take the adjacency down on the neighbor side. Hence we would be sending one empty hello packet. Since hello delivery is unreliable, there is no guarantee the empty hello will reach the router's neighbors. In this case, the adjacencies will time-out in router dead interval seconds. An exception of this is demand circuits where hellos are being suppressed (RFC 1793). This feature makes no attempt to handles this case as a more generalized solution is for the DC neighbors to periodically check the integrity of the adjacency as described in RFC - 3883 - "Detecting Inactive Neighbors over OSPF Demand Circuits"

Once the shutdown manager (Ref: ENG-251862, section 1.2.4) is available, we can have two option modes available: Reload and host-mode. The above mentioned implementation will be available as the reload option and we can hook the existing 'max metric' functionality to provide the host-mode option which would cause it to remain in "non-transit' mode. The host mode would be done upon the concept of RFC 3137/max-metric command which would set all the transit links to their maximum cost and hence traffic

would be diverted from this router. This would result in reduction of packet drop during graceful removal/shutdown of the router. So in this case, we would continue to maintain adjacencies advertise infinity metric (0xFFFF) for its connected links in Router LSA s and advertise normal interface cost in the link is a stub network.

At the interface level, it will shutdown the operation of OSPF on the interface only after we have sent the updated Router LSA (by removing the links associated with the interface where OSPF is being shutdown) over the interface, followed by one hello empty hello packet (as in the above case).

This feature would be implemented for both OSPFv2 and OSPFv3.

3   Software Requirements

Specified in the PRD: ENG-251862. The PRD talks about two different pieces of Graceful Shutdown requirement, which are the Shutdown manager and the protocol implementation. Since the shutdown manager is not yet implemented, the protocol implementation is done with the knowledge that someday there would be shutdown manager and they can then provide it with callback functions.

4   Memory and Performance Impact

There should be no additional memory requirement and no change to system performance.

5   Packaging Considerations

No new subsystem is introduced by this feature. Therefore, no special packaging instruction is needed for this feature.

6   End User Interface

There will be two different, but related sets of shutdown depending on whether the shutdown is occurring at the router/protocol level or at the interface/sub-interface level. The commands would be persistent (across reloads) at both router and interface level. For both OSPFv2 and OSPFv3, the CLI would be:

At the router level:

>   [no] shutdown

This causes the OSPF protocol to shutdown itself down completely and will put the routing instance in shutdown mode.

At the interface level:

[no] ip ospf shutdown

This will put OSPF under this interface in shutdown mode.

Once the shutdown manager is available, we can use it and the CLI can be enhanced to include the different options and phased shutdown. We can then also provide the host-mode option at the router level which will cause the system to remain in "non-transit" mode and will provide host-like functionality (i.e. one can telnet to it).

7 Configuration and Restrictions

No real restrictions for this CLI.

8 Testing Considerations

New test scripts need to be developed to test the functionality of this new feature.

Existing OSPF functionality need to be tested thoroughly through regression test.

- put an active OSPF interface into shutdown state
  - ➤ Check no adjacency is formed on this interface and all existing adjacency on this interface also gone,
  - ➤ Go to neighbor router to check the adjacency to this interface is gone.
  - ➤ Check show ip ospf neigh to make sure that all neighbors from this interface are also gone.
  - ➤ Check show ip route on other routers to see the route to the ip address is gone
  - ➤ Check no ospf hellos are sent from this interface
- put the interface back to enable
  - ➤ Check adjacency is formed
  - ➤ Check that the 'sh ip ospf neigh' shows all the neighbors in the correct state.
  - ➤ Check show ip route on other routers to see the route is back
- put the whole routing instance into shutdown state.
  - ➤ Check no adjacency formed on this router
  - ➤ Check show ip ospf database and it should only contain the router LSA for this router.
  - ➤ Check show ip route, all ospf routes from this routing instance should be gone.
  - ➤ Check no ospf hellos are being sent from any interface.
- put the whole routing instance into enable
  - ➤ Check adjacency formed on this router
  - ➤ Check show ip ospf database and it should show the populated database.
  - ➤ Check show ip route, all ospf routes from this routing instance should be back

9 Patentability Considerations

None.

10 Architecture Baseline Requirements

10.1 Product Evolution Program, PEP

None

10.2 Internet Protocol Version 6 (IPv6)

This feature will be implemented for OSPFv3 also.

10.3 IP Multicast

None

10.4 Quality Of Service (QoS)

None

11 Design Specifications for Reliability and Availability

None

12 References

- *ENG-251862*, Graceful Shutdown: Product Requirements Document
- *ENG-273857*, ISIS Protocol Shutdown: Software Unit Functional Spec
- *RFC 2328*, OSPF Version 2.

13 Glossary

The following list describes acronyms and definitions for terms used throughout this document:

- **IOS:**   Internetworking Operating System
- **OSPF**:   Open Shortest Path First interior gateway routing protocol
- **LSA**:   Link State Advertisement
- **VRF**:   VPN Routing and Forwarding Instance
- **RIB**:   Routing Information Base
- **SSO**:   Stateful Switchover
- **NSF**:   Nonstop Forwarding

- **ISIS**:   Intermediate System-to-Intermediate System interior gateway routing protocol
- **CLI**:   Command Line Interface

14 Attachments

As appropriate, attach log sheets, diagrams, schematics, usability research, examples of forms, or other pieces of information used in or generated in the production of the document.

14.1 Review Action Items

Use this section to log meeting minutes from the review of this document and to track review action items to closure. Relevant data includes meeting attendees, issues, and action items. Action item data includes description and owner, status (Open or Closed), and closure date.

In lieu of keeping the action item log here, this section may reference external review records, which capture and track the action items to closure. Examples of these external review records include Review Minutes checked into EDCS and review data captured via Peer Review Tool. http://wwwin.cisco.com/it/ese/IMF/PrtHome.html

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